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Section 1. Medical science

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PREDICTING BREAST CANCER USING ARTIFICIAL NEURAL NETWORK AND LOGISTIC REGRESSION

Abstract

Objective: This study aims to build a predictive model for breast cancer using artificial neural network and compare its performance to logistic regression model.

Methods: Wisconsin Diagnostic Breast Cancer (WDBC) data was used in this study. Features were computed from a digitized image of a fine needle aspirate (FNA) of a breast mass. They described characteristics of the cell nuclei present in the image.

All the participants who were eligible were randomly assigned into 2 groups: training sample and testing sample. Two models were built using training sample: artificial neural network and logistic regression. We used these two models to predict the risk of breast cancer in the testing sample. Receiver operating characteristic (ROC) were calculated and compared for these two models for their discrimination capability and a curve using predicted probability versus observed probability were plotted to demonstrate the calibration measure for these two models.

Results: A total of 569 patients were included in this analysis, 357 (62.74%) benign, 212 (37.26%) malignant breast cancer patients.

According to the logistic regression, number of concave portions of the contour and texture (standard deviation of gray-scale values) were at important predictors for malignant breast cancer.

According to this neural network, the top 5 most important predictors were worst area, mean of severity of concave portions of the contour, worst of severity of concave portions of the contour, worst of symmetry, worst of compactness.

For training sample, the ROC was 1.0 for the Logistic regression and 1.0 for the artificial neural network. Artificial neural network performed better clearly. While in testing sample, the ROC was 0.92 for the Logistic regression and 0.99 for the artificial neural network. Artificial neural network had better performance.

As to calibration measure, predictions made by the neural network are (in general) less concentrated around the 45-degree line (a perfect alignment with the line would indicate an ideal perfect calibration) than those made by the Logistic model.

Conclusions: In this study, we identified several important predictors for breast cancer e.g., number of concave portions of the contour, worst of symmetry, worst of compactness. This provided

important information for providers and patients for timely accurate diagnosis. We built a predictive model using artificial neural network as well as logistic regression to provide a tool for timely accurate diagnosis. When compared to artificial neural network model, logistic regression had a worse discriminating capability and a better calibration between predicted probability and observed probability.

Keywords: Breast Cancer, Statistics.

1. Instruction

In the United States, breast cancer is the most common cancer in women. Breast cancer is a disease in which cells in the breast grow out of control. There are different kinds of breast cancer. The kind of breast cancer depends on which cells in the breast turn into cancer. In 2014, 236,968 women and 2,141 men in the United States were diagnosed with breast cancer. A total of 41,211 women and 465 men in the United States died from breast cancer in 2014 [1].

Women who have changes in certain breast cancer genes (BRCA1 and BRCA2), or have close relatives with these changes have increased risk of breast cancer [2]. About 12 percent of women in the general population will develop breast cancer sometime during their lives (4). By contrast, according to the most recent estimates, 55 to 65 percent of women who inherit a harmful BRCA1 mutation and around 45 percent of women who inherit a harmful BRCA2 mutation will develop breast cancer by age 70 years [3]. Other risk factors include Ashkenazi Jewish heritage, treatment with radiation therapy to the breast or chest during childhood or early adulthood according to the US Centers for Disease Control and Prevention [4].

This study aims to: 1) examine the predictors of breast cancer; 2) build a predictive model for breast cancer using artificial neural network and compare its performance to logistic regression model.

2. Data and Methods:

Data:

Wisconsin Diagnostic Breast Cancer (WDBC) data was used in this study. Features were computed from a digitized image of a fine needle aspirate (FNA) of a breast mass. They described characteristics of the cell nuclei present in the image [5].

It is a public data avaialble at: URL: http://archive.ics.uci.edu/ml/datasets/breast+cancer+wisconsin+%28diagnostic%29

Models:

Artificial neural netwrok consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In more practical terms neural networks are non-linear statistical data modeling tools. They can be used to model complex relationships between inputs and outputs or to find patterns in data. Using neural networks as a tool, data warehousing firms are harvesting information from datasets in the process known as data mining. The difference between these data warehouses and ordinary databases is that there is actual anipulation and cross-fertilization of the data helping users makes more informed decisions.

A package called "neuralnet" in R was used to conduct neural network analysis. The package neuralnet focuses on multi-layer perceptrons (MLP, Bishop, 1995), which are well applicable when modeling functional relationships. The underlying structure of an MLP is a directed graph, i.e. it consists of vertices and directed edges, in this context called neurons and synapses. The neurons are organized in layers, which are usually fully connected by synapses. In neuralnet, a synapse can only connect to subsequent layers. The input layer consists of all covariates in separate neurons and the output layer consists of the response variables. The layers in between are referred to as hidden layers, as they are not directly observable. Input layer and hidden layers include

a constant neuron relating to intercept synapses, i.e. synapses that are not directly influenced by any covariate Neural networks are fitted to the data by learning algorithms during a training process. Neuralnet focuses on supervised learning algorithms.

The backward propagation of errors or backpropagation, is a common method of training artificial neural networks and used in conjunction with an optimization method such as gradient descent. The algorithm repeats a two phase cycle, propagation and weight update. When an input vector is presented to the network, it is propagated forward through the network, layer by layer, until it reaches the output layer. The output of the network is then compared to the desired output, using a loss function, and an error value is calculated for each of the neurons in the output layer. The error values are then propagated backwards, starting from the output, until each neuron has an associated error value which roughly represents its contribution to the original output.

We also used logistic regression models to calculate the predicted risk. Logistic regression is a part of a category of statistical models called generalized linear models, and it allows one to predict a discrete outcome from a set of variables that may be continuous, discrete, dichotomous, or a combination of these. Typically, the dependent variable is dichotomous and the independent variables are either categorical or continuous.

The logistic regression model can be expressed with the formula:

$$ln(P/P-1) = \beta_0 + \beta_1{}^*X_1 + \beta_2{}^*X_2 + \ldots .+ \beta_n{}^*X_n$$

Model evaluation:

The two criteria to assess the quality of a classification model are discrimination and calibration. Discrimination is a measure of how well the two classes in the data set are separated; calibration determines how accurate the model probability estimated is to the true probability. To provide an unbiased estimate of a model's discrimination and calibration, these values have to be calculated from a data set not used in the model building process. Usually, a portion of the original data set, called the test or validation set, is put aside for this purpose. In small data sets, there may not be enough data items for both training and testing. In this case, the whole data set is divided into n pieces, n_1 pieces are used for training, and the last piece is the test set. This process of n-fold cross-validation builds n models; the numbers reported are the averages over all n test sets. An alternative to cross-validation is bootstrapping, a process by which training sets are sampled with replacement from the original data sets.

The discriminatory ability – the capacity of the model to separate cases from non-cases, with 1.0 and 0.5 meaning perfect and random discrimination, respectively– was determined using receiver operating characteristic (ROC) curve analysis. ROC curves are commonly used to summarize the diagnostic accuracy of risk models and to assess the improvements made to such models that are gained from adding other risk factors. Sensitivity, specificity, and accuracy will be also calculated and compared. For all these measures, there exist statistical tests to determine whether one model exceeds another in discrimination ability.

The contingency table can derive several evaluation "metrics" (see infobox). To draw a ROC curve, only the true positive rate (TPR) and false positive rate (FPR) are needed (as functions of some classifier parameter). The TPR defines how many correct positive results occur among all positive samples available during the test. FPR, on the other hand, defines how many incorrect positive results occur among all negative samples available during the test.

A ROC space is defined by FPR and TPR as x and y axes respectively, which depicts relative trade-offs between true positive (benefits) and false positive (costs). Since TPR is equivalent to sensitivity and FPR is equal to 1 – specificity, the ROC graph is sometimes called the sensitivity vs (1 – specificity) plot. Each prediction result or instance of a confusion matrix represents one point in the ROC space.

The best possible prediction method would yield a point in the upper left corner or coordinate (0,1) of the ROC space, representing 100% sensitivity (no false negatives) and 100% specificity (no false positives). The (0,1) point is also called a perfect classification. A random guess would give a point along a diagonal line (the so-called line of no-discrimination) from the left bottom to the top right corners (regardless of the positive and negative base rates). An intuitive example of random guessing is a decision by flipping coins. As the size of the sample increases, a random classifier's ROC point migrates towards the diagonal line. In the case of a balanced coin, it will migrate to the point (0.5, 0.5).

The diagonal divides the ROC space. Points above the diagonal represent good classification results (better than random), points below the line represent poor results (worse than random). Note that the output of a consistently poor predictor could simply be inverted to obtain a good predictor.

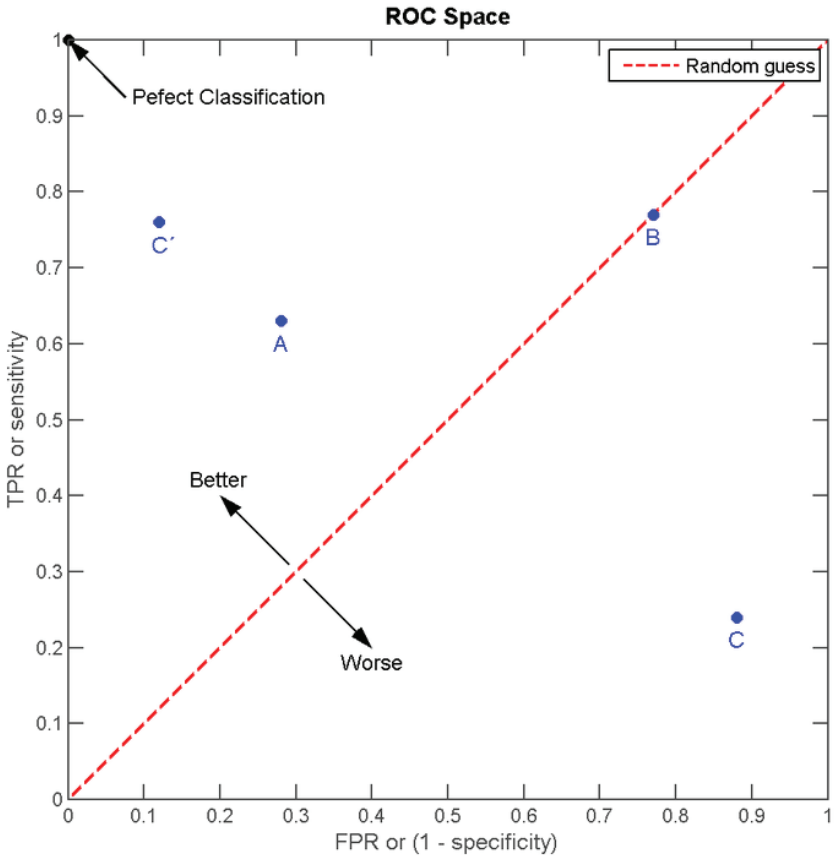

Figure 1.

Calibration is a measure of how close the predictions of a given model are to the real underlying probability. Almost always, the true underlying probability is unknown and can only be estimated retrospectively by verifying the true binary outcome of the data being studied. Calibration thus measures the similarity between two different estimates of a probability. One of the ways to assess calibration is to take the difference between the average observation and the average outcome of a given group as a measure of discalibration. A more refined way to measure calibration requires dividing the sample into smaller groups sorted by predictions, calculating the sum of predictions and sum of outcomes for each group, and determining whether there are any statistically significant differences between the expected and observed numbers by a simple method.

Variables:

The outcome variable is where or not the patients had breast cancer based on variable called Diagnosis (M = malignant, B = benign).

Ten real-valued features are computed for each cell nucleus as below.

Table 1.– Independent variables used in this study

a) radius (mean of distances from center to points on the perimeter)
b) texture (standard deviation of gray-scale values)
c) perimeter
d) area
e) smoothness (local variation in radius lengths)
f) compactness (perimeter^2 / area – 1.0)
g) concavity (severity of concave portions of the contour)
h) concave points (number of concave portions of the contour)
i) symmetry
j) fractal dimension («coastline approximation» – 1)

The mean, and "worst" or largest (mean of the three largest values) of these features were computed for each image, resulting in 20 features. In this study, we did not use standard error features in our predictive modeling exercises. All feature values are recoded with four significant digits.

3. Results

A total of 569 patients were included in this analysis, 357 (62.74%) benign, 212 (37.26%) malignant breast cancer patients.

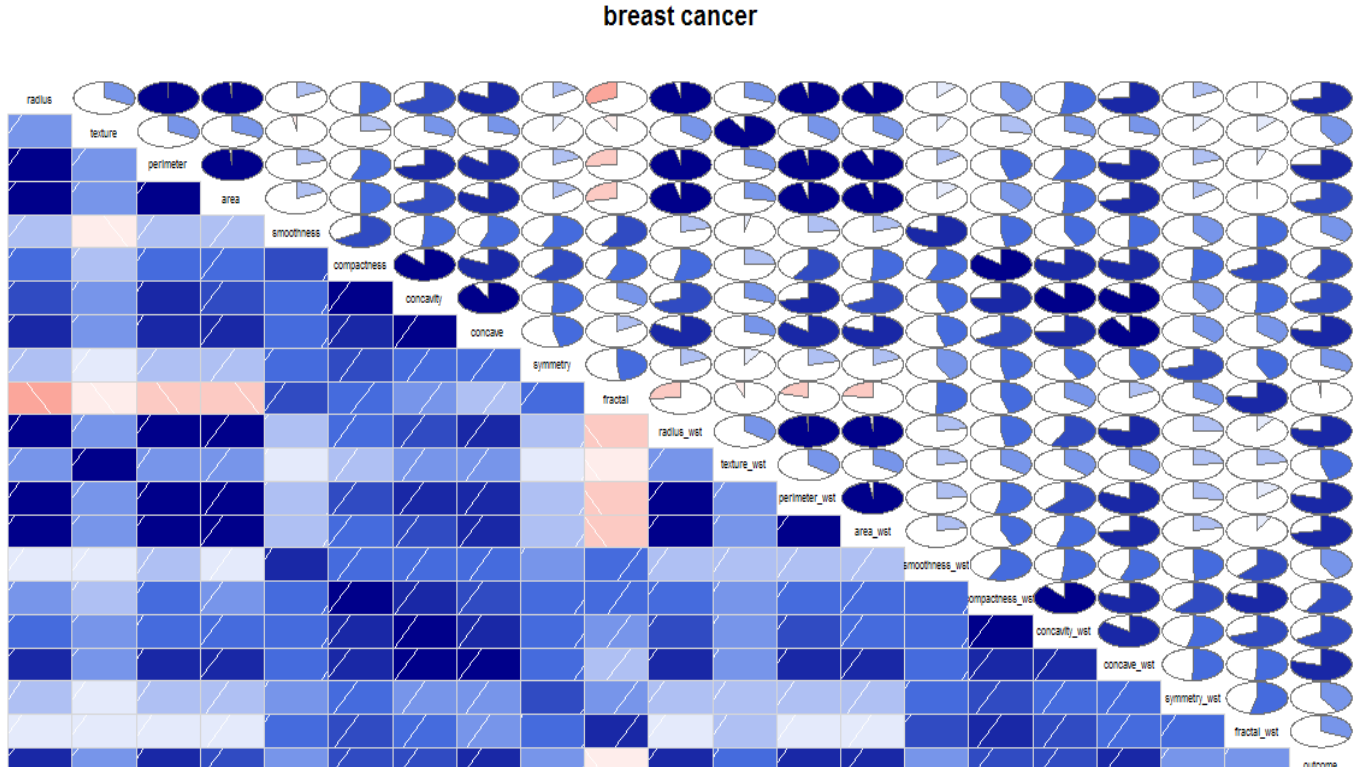

Figure 2. Matrix of correlations between variables

Basically, a corrgram is a graphical representation of the cells of a matrix of correlations. The idea is to display the pattern of correlations in terms of their signs and magnitudes using visual thinning and correlation-based variable ordering. Moreover, the cells of the matrix can be shaded or colored to show the correlation value. The positive correlations are shown in blue, while the negative correlations are shown in red; the darker the hue, the greater the magnitude of the correlation.

According to the logistic regression, number of concave portions of the contour and **texture** (standard deviation of gray-scale values) were at important predictors for malignant breast cancer.

Table 2.– Logistic Regression for Breast cancer

	Estimate	**Std. Error**	**Z value**	**Pr(>|z|)**	
radius	–4.504	8.840	–0.510	0.610	
texture	0.446	0.233	1.909	0.056	.
perimeter	0.448	1.163	0.385	0.700	
area	–0.007	0.046	–0.147	0.883	
smoothness	73.631	93.831	0.785	0.433	
compactness	–102.930	64.562	–1.594	0.111	
concavity	–3.555	29.443	–0.121	0.904	
concave	159.129	71.754	2.218	0.027	*
symmetry	11.164	27.505	0.406	0.685	
fractal	61.836	241.244	0.256	0.798	
radius_wst	0.789	2.674	0.295	0.768	
texture_wst	0.042	0.146	0.288	0.773	
perimeter_wst	–0.053	0.206	–0.255	0.799	
area_wst	0.027	0.025	1.094	0.274	
smoothness_wst	17.425	39.766	0.438	0.661	
compactness_wst	10.043	13.414	0.749	0.454	
concavity_wst	5.233	8.402	0.623	0.533	
concave_wst	6.984	24.042	0.290	0.771	
symmetry_wst	6.791	10.278	0.661	0.509	
fractal_wst	–25.984	83.068	–0.313	0.754	

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

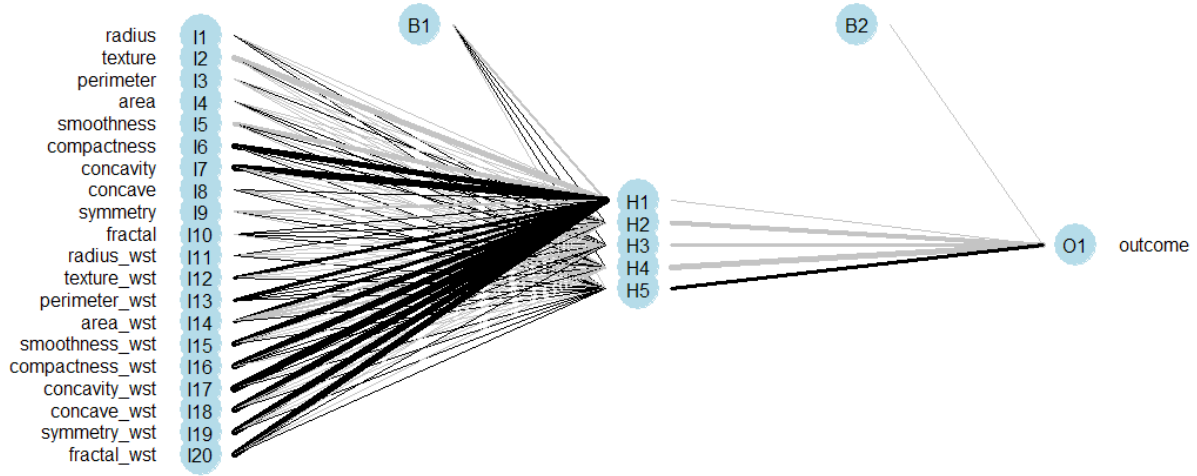

Figure 3. Artificial Neural Network in training sample

In above plot, line thickness represents weight magnitude and line color weight sign (black = positive, grey = negative). The net is essentially a black box so we cannot say that much about the fitting, the weights and the model. Suffice to say that the training algorithm has converged and therefore the model is ready to be used.

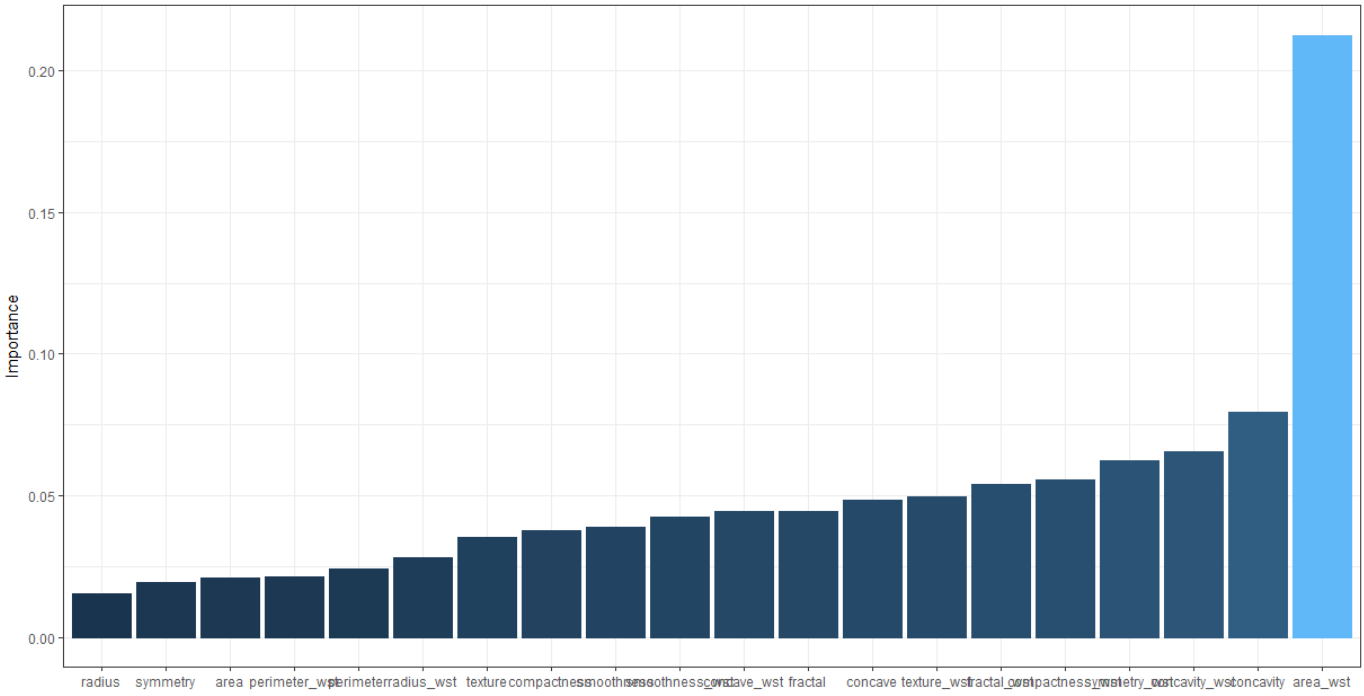

Figure 4. Variable Importance in Artificial Neural Network

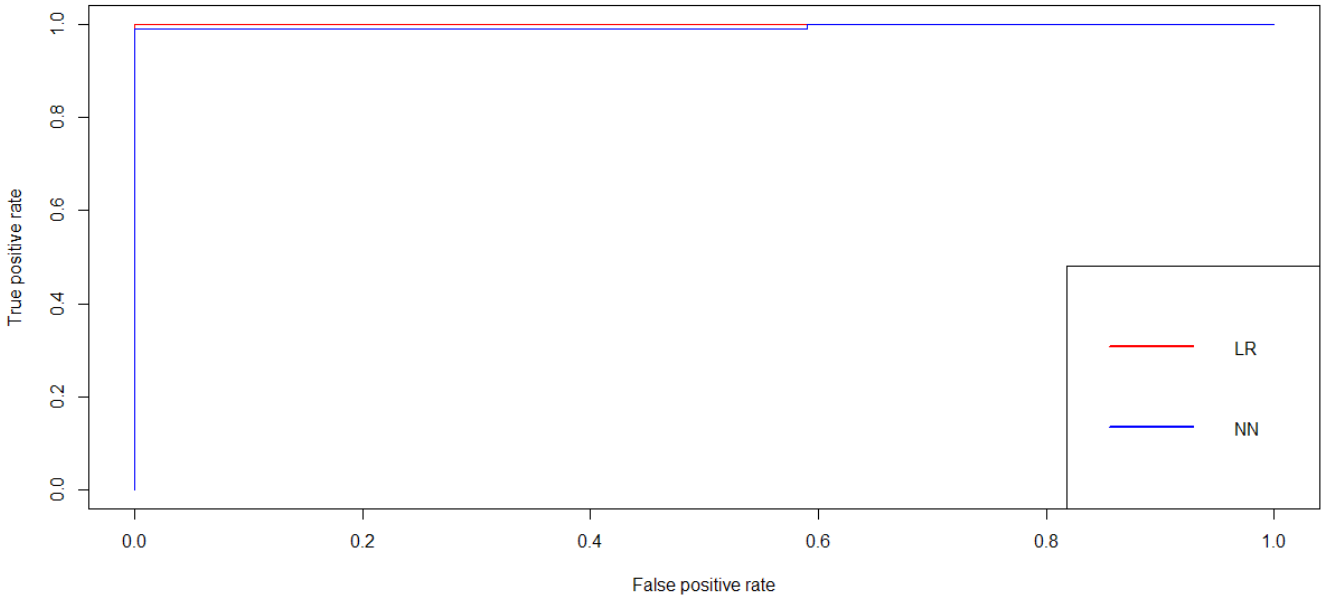

Figure 5. ROC in training sample for Logistic Regression (Red) vs Neural Network (Blue)

According to this neural network, the top 5 most important predictors were worst area, mean of severity of concave portions of the contour, worst of severity of concave portions of the contour, worst of symmetry, worst of compactness.

For training sample, the ROC was 1.0 for the Logistic regression and 1.0 for the artificial neural network. Artificial neural network performed better clearly. However in testing sample, the ROC was 0.92 for the Logistic regression and 0.99 for the artificial neural network. Artificial neural network had better performance.

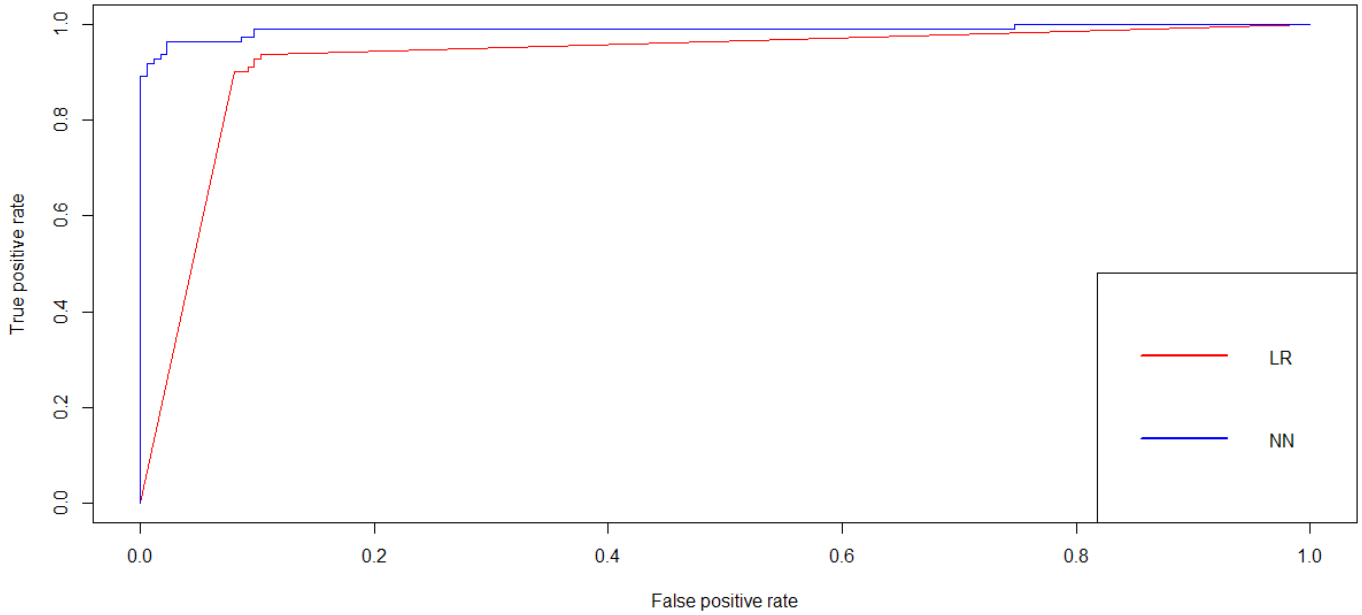

Figure 6. ROC in testing sample for Logistic Regression (Red) vs Neural Network (Blue)

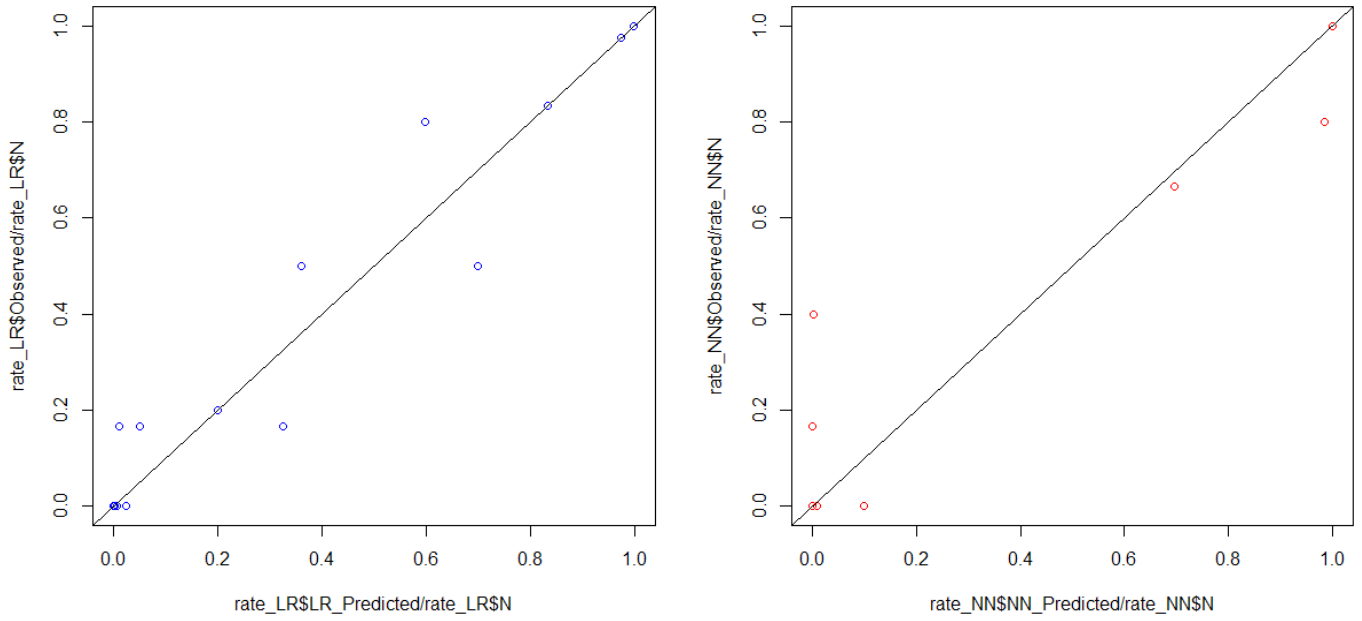

Figure 7. Predicted Probability vs. Observed Probability in testing sample for Logistic Regression (Red) vs Neural Network (Blue), sorted by predicted probability

By visually inspecting the plot we can see that the predictions made by the neural network are (in general) less concentrated around the line (a perfect alignment with the line would indicate an ideal perfect calibration) than those made by the Logistic model.

4. Discussions

In this study, we built a predictive model using artificial neural network as well as logistic regression to provide a tool for timely accurate diagnosis.

We identified several important predictors for breast cancer e.g., number of concave portions of the contour, worst of symmetry, worst of compactness. This provided important information for providers and patients for timely accurate diagnosis. Meanwhile we noticed that artificial neural network identified different predictors of great importance from predictors identified by logistic regression. It highlights the importance to explore new data mining techniques when building a predictive model.

Some known factors which might predict of breast cancer were not available in this study, like family history of breast cancer. According to the literature, women were at increased risk of breast cancer if they had close relatives (parents, siblings, or children) who were diagnosed with breast or ovarian cancer when they were younger than 45, especially if more than one relative was diagnosed or if a male relative had breast cancer.

We did not test the external validity neither for logistic regression nor for the ANN. However, we did a comprehensive split-sample validation with both strategies. Future studies could use outside data and test the performance of the outputs from these two models in this study.

A predictive model would be an extremely useful tool to timely diagnose breast cancer. When the variables included in our tool are available, the diagnosis could be acutely made. When compared to artificial neural network model, logistic regression had a worse discriminating capability and a better calibration between predicted probability and observed probability.

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Section 2. Pedagogy

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USİNG PROJECT-BASED LEARNİNG TO BUİLD SKİLLS İN BİOLOGY LESSONS

Abstract. The article emphasizes the advantages of Project-based learning in building skills in biology teaching. Working on projects not only contributes to the development of students' critical thinking and creative abilities but also increases their motivation to learn.

Keywords: project, extracurricular activity, research, biology, problem-oriente.

The article emphasizes the advantages of Project-based learning in building skills in biology teaching. Working on projects not only contributes to the development of students' critical thinking and creative abilities but also increases their motivation to learn. One of the most important conditions for increasing the effectiveness of the educational process is the organization of project-research activities and the development of research skills, which are its main component. However, currently, most secondary school teachers don't use the project method in biology teaching. Knowledge is given to students ready-made, it isn't got independently, and no search for additional information is required.

The main task of the modern school is to raise people who "learn to learn". Perspectively, the student should solve the problem, search for information, look for ways to solve the problem, analyze the solution results and improve the research activity. Project-based learning makes the educational process more efficient because the learner better assimilates the knowledge acquired and can choose the optimal set of knowledge required in life. Project-based learning is based on constructivism [1, 66].

Project-based learning owes its origin to the American philosophers who belonged to the pragmatic school of philosophy. The main supporter of this method was U. Kilpatrick [2, 161]. He was influenced by John Dewey's principle of pragmatism. Kilpatrick defined the project as a "purposeful activity" by using these ideas. According to Kilpatrick, projects had four phases: goal setting, planning, implementation, and evaluation. Ideal progress occurs when all four phases begin and end with the students, not the teacher. In his opinion, when students use "freedom of action", they can get independence, judgment, and ability to act.

Features of project-based learning include the followings:

- Projects are student-oriented. Students have the autonomy to make decisions about all aspects of the project;
- Projects are problem-oriented. The problem plays a leading role in the organization of concepts and principles, guides and directs activities;
- The results expected are cognitive and practical;
- Students interact with the real world through projects.

- Projects are implemented within the framework of cooperation. Projects require working together to achieve a goal;
- Projects usually involve multiple disciplines;
- Projects take a lot of time.

Below is a list of a few skills developed through project-based learning.

Information-seeking skills:

- create independently ideas based on knowledge from different fields;
- create independent ideas, learn from different fields;
- independently find missing information in the knowledge area;
- find several options to solve the problem;
- hypothesize;
- establish cause-effect relationships.

Collaboration Skills:

- collective planning;
- interact with partners;
- help each other as a group in solving common problems;
- business partnership communication skills;
- the ability to find and correct errors in the work of other members of the group.

Communication capabilities:

- participate in discussions;
- defend your point of view;
- find a compromise;
- interview, query.

Presentation skills:

- monologic speech skills;
- act confidently;
- the ability to use different visual aids during a speech;
- ability to answer unplanned questions.

Management Skills:

- planning activities, time, resources;
- make decisions and predict their consequences;
- analyze their performance;

Different types of projects can be used in biology lessons. The implementation of the research project can be implemented both in the classroom and in extracurricular activities. The research project can be linked to environmental protection and the solution of regional ecological problems. The subject of the project called "Restoration of the area you live in" is of a research nature.

In a role-playing project, the conclusion is unknown until the end. For example, when the 8th-grade project "Our organ systems work regularly", each student plays the role of a certain organ, talks about its functions and importance in the body, and models different situations and their solutions.

Practical projects are aimed at the interests of students and in most cases, the solution to social problems. Such a project requires a well-thought-out structure, even defining the scenario of all the activities of its participants, the function of each and the precise results of the joint activities. Practical projects are mostly group projects where students participate in nature conservation actions and thematic competitions. This can be cleaning the school area of plastic containers, paper, and other waste.

The information project aims for teaching students to independently obtain the necessary information. The use of ICT tools allows to significantly reduce the time of information collection and, consequently, working time on the project. "Biodiversity in Ecosystems", "Genome Modified Organisms", "Cloning" are information-oriented projects in terms of content.

Designing creative projects requires maximum independence and a creative approach. "Creating crafts from waste materials", "Preparing a stress-fighting video" are examples of such projects.

While preparing a design project on "Modelling the structure of the protein molecule", students build the model using different materials based on the knowledge of the primary, secondary, tertiary, and quaternary structure of the protein molecule.

In the "Mutations" research project, students study mutagenic factors, their origin, the role of

mutations in modern human life, and hypothesize that mutations cause many hereditary diseases and birth defects in humans. Consequently, the students concluded that mutations can occur spontaneously and under the influence of various mutagenic agents, and that mutations are the cause of many hereditary diseases and birth defects in humans.

The research project "Effect of food additives on health" reviews information about food additives and their role in modern food production, food indices, and types of food flavorings. Students determine the classification of food additives, which food additives are prohibited and the effect of food additives on human health. Consequently, concluded that all food products contain food additives. Most teens consume foods that contain food additives. Food additives in chips, crackers, chewing gum have a harmful effect on students' health. Canned foods and semi-finished products should not be given to children of preschool and primary school age.

In the research project "The effect of mobile phones on the human body", the author studies the impact of mobile phones on human health, conducts sociological research, analyzes scientific materials, explains the harm caused by mobile phones to human health, analyzes the problems experienced during mobile phone use. Pursuant to the results of sociological research, the majority of mobile users believe that phones affect their health, but they continue to use them because they are very convenient. So far, there are no reliable facts proven about the harmful effects of using phones, but they were not proven to be completely safe either.

The project "Pandemics of the Past Compared to the COVID-19 Pandemic" is a current research project. Students study the historical aspect of the pandemic, define this concept, learn about pandemics humanity faced before, and the conditions of a real pandemic. Students conduct a comparative analysis of statistics on deaths from the coronavirus with other diseases causing a pandemic, they research all aspects of the new disease, whether COVID-19 disease is as dangerous as it is portrayed in all the media and whether humanity will be destroyed by COVID-19.

It is impossible to apply the project method without the teacher's organizational and creative, nonstandard approach. Teachers act more as a guide, adviser, motivator, facilitator and evaluator [3, 254]. In practice, this leads to a change in the teacher's position. The teacher turns from the carrier of ready knowledge to the organizer of the cognitive activity of the students. That is why the teacher should build the activity pursuant to the followings:

- involving the student in the process of solving important, integrative, and creative problems;
- cognitive and practical significance of the expected results;
- sharing information that will motivate students' creative activities and encourage them to be creative;
- developing the skills to work in a team, to show tolerance and respect, which will help to solve problems and get out of conflict situations;
- teaching to think independently, find and solve problems, attract integrative knowledge, predict the conclusions and possible consequences of various solutions, find cause-effect relationships;
- forming the skills of collecting and processing information, materials;
- establishing the ability to prepare a written report;
- building the ability to analyze, including creativity and critical thinking;
- forming the ability to prepare and conduct a presentation of study results.

Thus, the integrity of the pedagogical process is ensured during the application of the project-based learning model, which is person-oriented, conditions are created for independent knowledge acquisition, interdisciplinary integration is ensured, a transition

from the school of memory to the school of thought is formed, positive motivations for self-education are formed, directed to the future profession and higher education.

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Section 3. Sociology

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READING ON IPAD VERSUS PAPER: A BEHAVIORAL EXPERIMENT

Abstract. With the growing popularity and accessibility of digital reading devices, questions regarding their effect on reading comprehension arise. Fifty- four college students were randomly assigned to either experimental group or control group. Participants in the experimental group read a two-page text on an iPad and participants in the control group read the same two-page text on a piece of paper. After the 15-minutes of reading, participants completed 10 SAT questions that measured their reading comprehension on abstract information and detailed information from the two-page text. Multiple-regression analysis results showed that the two groups differed only on their comprehension of the abstract information. Besides the group factor, time spent on completing the SAT questions also predicted participants' scores on abstract questions. Consistent with some previous studies, there were no significant differences in the overall scores between the iPad and paper groups.

Keywords: reading comprehension, digital media, reading speed, technology, narrative text**.**

With the digital age, technology has been quietly replacing traditional media in a plethora of environments. When one walks into a library, they will inevitably see someone working on a laptop. Technology brings the convenience of being able to access an abundance of information via the internet freely. Tablets are able to store millions of words without the user having to carry around heavy books. Consumers also gain the ability to record their process with an e-reader easily. E-readers also have search functions, which allow the user to quickly look up a specific word or phrase in a piece of writing. A study on Korean middle school students showed that 30.9% of the students were at risk of smartphone addiction (Cha and Seo [2]). The prevalence of digital media is easily identifiable.

Though technology offers many advantages compared to paper, educators still have concerns about how effective it is to read on digital media. Many teachers worry about students being more distracted when using an iPad, as compared to print media. Some students felt eye strain, were more distracted, and had increased anxiety due to the number of choices of e-textbooks (Dobler [8]). Parents also worry about whether digital media negatively affects memory. Other worries about the possible degrees of critical thinking, which positively affects reading comprehension and only occurs when the reader is deeply concentrated (Elder & Paul [12]; Hosseini et al. [14]).

Many studies show that print materials support better comprehension of the text compared to paper materials. Other studies show that reading on paper results in a deeper understanding of the text than reading on a screen (Öztop & Nayci [18]; Gąsior [13]). Öztop and Nayci's study was a meta-analysis of 12 studies, that involved reading in Turkish.

Gąsior's study consisted of Polish English learners reading the same text on either paper or computer screen. Many researchers such as Öztop and Nayci recommend "improving the screen interface and screen reading skills". When participants were in a stressful environment, they understood the text least when reading on-screen than on paper (Delgado & Salmerón [7]). However, other studies such as "Screen and Paper Research" found that there were no significant differences in comprehension when reading from an e-reader versus paper (Walsh [9]).

Activity Theory may explain the difference in results of reading on the two media. Studies such as "An application of activity theory to the "problem of e-books" explains that due to a decrease of continuity of tasks, digital media diminish organization in studying and working (Kirby & Anwar [1]). The researchers applied Activity Theory to explain the cognitive processes that occur when participants read on an e-reader. Other studies present the selective attention theory called "Thought Suppression" (Chajut and Algom [15]). When processing information, humans can block off other things in the environment. Digital media may make this process more difficult. The theory of Thought Suppression suggests that people can select what they want to focus their attention on. When stressed, the brain struggles with the intended object of focus and becomes distracted. More automatic processes such as flipping a sheet of paper require less energy and provide fewer distractions (Chajut and Algom [16]). Digital media may be more tedious to navigate, forcing the brain to diverge more energy. For example, when students use paper to take the SAT, they are already familiar with the paper as a reading media. They do not need to diverge additional energy to operate the additional features that an iPad may offer. The additional highlighter, underlighting, note-taking tools, and more on an iPad are helpful features for the user in a low-stress environment. In high-stress environments, however, the additional hand-eye coordination puts additional stress on the user. These may consume attention and make blocking distractions more difficult. In addition, the participants only comprehend the small details in the materials. Abstract questions require information integration, which in turn requires a deep understanding of the text (Chi et. al [4]). Only understanding the smaller ideas and not the overall picture may bring down the overall test score and the abstract score of the iPad group.

The reaction time may also correlate with performance. One such study shows that a faster reaction time is correlated with higher accuracy. However, a decrease in comprehension was shown when reading fast (Dyson & Haselgrove [11]). Dyson and Haselgrove found that medium-lengthed sentences contribute to the best comprehension ability. Longer scrolling time and pauses were also correlated with higher performance. Reading faster may cause readers to skip over certain essential pieces of information. They could also misremember details and insert words where there were not. Spending more time rereading text could increase the detail and abstract section scores, effectively raising the overall score.

Current Study

In this study, there were three different means of measuring comprehension. The overall score measures the general comprehension of the participant. The detailed score measures how well the participant understood details in the reading material. Finally, the abstract score measures the participant's understanding of the overall passage.

This paper aims to discuss the difference in reading comprehension in young people when reading from paper or an iPad. Students were measured by a combination of abstract and detailed questions. Abstract questions tested the participants' understanding of the more profound message the reading conveys. To answer them correctly, participants will have to gain an adequate understanding of the entire passage. To answer them correctly, participants will have to remember their rough position and go back to the passage and find the answer. It is hypothesized that the paper group will do better overall and

in abstract questions. The iPad group will do better in the detailed questions.

Method

Participants

College students from a metropolitan city in China participated in the current experiment. Any genders were welcome to the experiment. The study procedure was approved by the IRB at the study site.

Procedure

Participants were invited to the lab individually by appointment. A trained research assistant greeted the participants and read the consent form to them. Participants were able to ask questions about the form and the researcher assistant answered them. The participants were then seated in front of either an iPad or a piece of paper, containing the same passage. Both media were the same size and the same font. Participants had 15 minutes to read the passage. The passage was an excerpt from a novel. They were allowed to write down words they did not know because the passage was in English and their native language was Chinese. Afterward, they were given a dictionary to look up unfamiliar terms. Then they were asked to complete the 10 SAT questions about the reading material on either an iPad or a piece of paper. They still had access to passages and the dictionary during the testing time. The participants were allowed as much time as they needed to complete the SAT reading comprehension questions. In the end, participants completed simple demographics questions such as their major, gender, and age. The participants were then thanked and compensated about 4.63 dollars (30 RMB) for their time. The entire procedure took less than one hour. The SAT questions were found online and were publicly available practice questions for SAT reading comprehension section.

Variables

Media. A binary variable was used to denote whether the participants were assigned to the iPad or paper groups. This variable was entered in the multiple regression models as a binary categorical variable. **Total score**. A total of 10 multiple-choice questions were used to measure participants' reading comprehension of the materials. **Abstract score.** Abstract information comprehension was measured using five of the ten questions. An example question used to measure abstract information comprehension was "Which choice best describes what happens in the passage?" **Detail score.** Detail information comprehension was measured using the other five of the ten questions. An example question used to measure detailed information comprehension was "As used in line 1 and line 65, 'directly' most nearly means?" The correct response was recorded as 1 and the incorrect was recorded as 0. If the participant left the answer blank, it was recorded as N/A. **Time.** The length of time participants spent on each section was also recorded. The results were inputted into R studio and were analyzed using multiple regression using package "rstatix".

Results

Controlling for age, gender, time spent completing the questions, and interaction between media and time, the media group did not significantly predict the total score ($\beta = -2.57$, $p = 0.59$), meaning that the two groups did not differ significantly on their total scores. This model achieved small effect size ($R^2 = 0.07$) according to Cohen's criteria (Cohen, 1988). Once again, the two groups scored similarly in the detailed questions of the SAT. Media group did not significantly predict detail score neither ($\beta = 1.40$, $p = 0.4$). This model achieved a small effect size ($R^2 = 0.10$) according to Cohen's criteria. Again, media was not a significant coefficient. In the abstract questions of the test, media was significant. Media group significantly predicted abstract score ($\beta = -3.96$, $p < 0.05$), with the paper group showing higher abstract scores. This model achieved medium effect ($R^2 = 0.20$).

Time spent to complete the questions was not a significant predictor for neither total score more detail score. Time spent to complete the ten questions, however, was a significant predictor for abstract score

($\beta = -0.01, p < 0.01$). Longer time spent completing the ten questions predicted lower abstract scores.

Both the interactions between time and media for the overall and detail scores were insignificant, with the overall score's p-value being –3.96 and the detail score's p-value being 0.5759. Participants who used an iPad to take the SAT and spend more time on it were able to get higher scores on the abstract questions. The interaction between the variables time and media shows a significant effect on abstract scores ($\beta = = 0.006, p < 0.01$). Specifically, for the iPad group, longer time spent completing the questions predicted higher abstract scores ($\beta = -0.001, p = 0.19$). (Fig. 1) shows the line graph for the interaction effect.

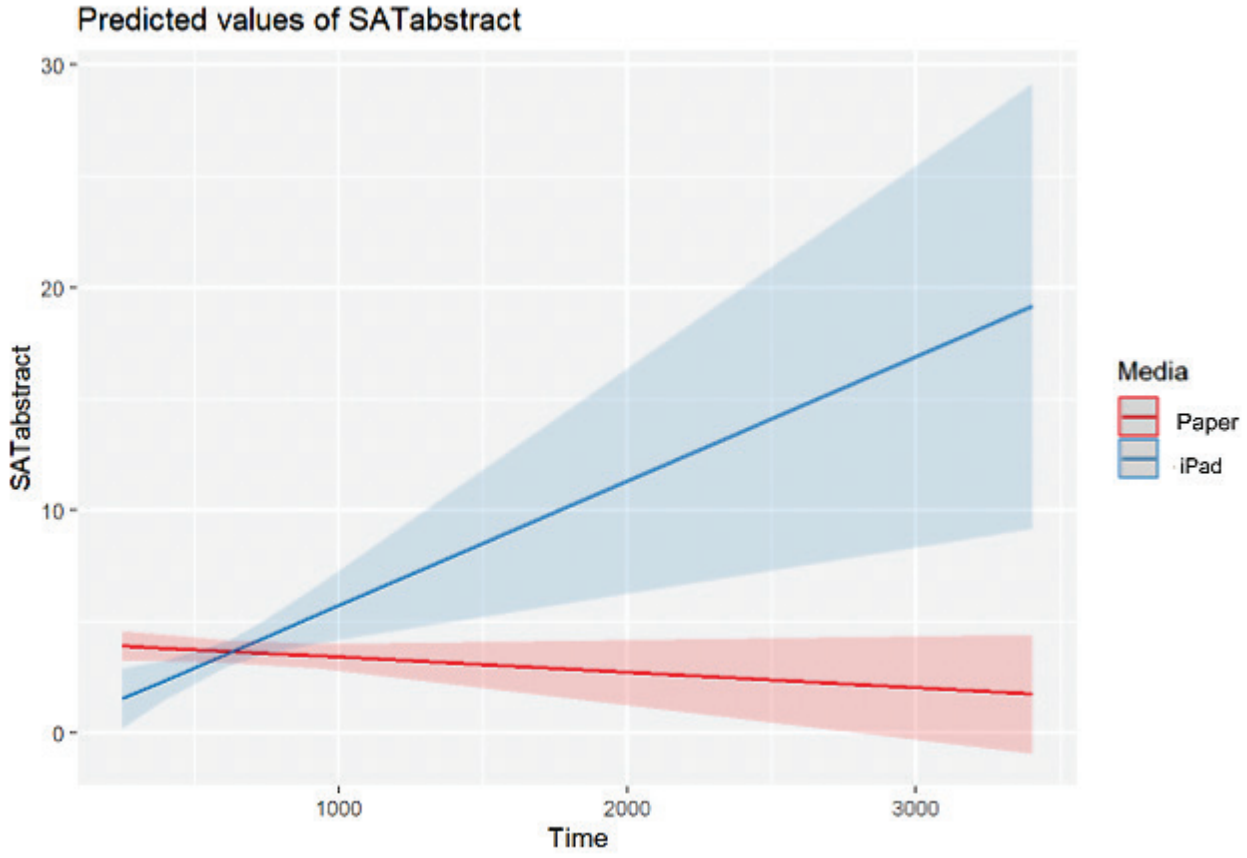

Figure 1. Predicted value of SAT abstract score in correlation with time for the paper group and iPad group

Discussion

Due to growing concerns with parents and educators about the influence of digital media in classrooms, this report was conducted to research the different aspects of reading comprehension in digital media versus paper media. This study shows that overall, the two different media do not show many differences in reading comprehension.

In the current study, there was no overall difference between the test scores of all the participants. There was also no difference in the detail sections of the SAT of all the participants' scores. However, in the abstract section, the paper group achieved higher scores. The study was conducted by asking college students to take the SAT on either an iPad or paper. In addition, the participant's age, gender, and time took for the test were controlled.

The hypothesis states that the paper group will score higher on both the overall score and abstract questions. The results of the data analysis showed that there was no difference between the media on participants' overall results. Other studies showed

that "comprehension of the digital text was inferior to that of the printed text" (Ben-Yehudah & Eshet-Alkalai [19]). Their results contradict the current study's findings. Another research paper states that, compared to paper, digital media has negatively affected the user's reading comprehension (Clinton [5]). This supports the initial hypothesis. However, the author acknowledged that the results might be limited since only expository texts were present in the study. The inconsistencies in the studies may be down to questions difference, as the study by Ben-Yehudah & Eshet-Alkalai had mostly abstract questions. The study by Clinton did not state if the questions were abstract or detail-based.

Next, the hypothesis states that the iPad group will score higher on the detail questions. The results showed that, once again, the two groups did not have significant differences in this section. With a p-value of over 0.05, media did not prove to be the variable of difference. The hypothesis states that the longer the iPad group spends on the detail section, the higher their score. However, the data analysis shows that the iPad group only had a positive time and media interaction effect on the abstract items (β=0.006, $p < 0.05$). The hypothesis then states that the paper group will score higher on the abstract questions. This was proven true as the data had a p-value <0.05.

Thought Suppression Theory may explain the difference between the results and hypothesis. This theory suggests that people can repress distracting thoughts or outside elements to focus on the task at hand. Since this is a controlled experiment, the researcher assistant eliminated most of the daily life distractions for the participants. This may help the iPad group block out distractions more easily than shown in previous studies. Because there was a switch of mediums when the iPad group was studying versus taking the SAT (from iPad to a laptop), this might take extra adjusting. However, if the user has plenty of experience with either digital media, taking the test on either would not significantly impact performance (Ling [9]).

Additionally, the iPad group had access to highlighter tools. Previous research has shown that highlighting important texts help improve memory and attention (Nishimur & Kuwahara [17]). The iPad group also could use the provided notepad inside the program in which the participants took the test. Studies have shown that note-taking under time restraints reduced the students' distractedness and increased performance (Wu & Xie [2]). Therefore the paper group may have been able to perform even better if they were provided with the same materials.

Limitations

Of course, there are many limitations to the present study. First, this study only studied the difference between reading on iPad and reading on paper; it does not include other e-reader devices. A Kindle may be less or more distracting than an iPad because of the different screen textures. Future studies could include more media for participants to read on. Additionally, this study only included college-age students. A different age group may not achieve the same results. For example, toddlers may be much more distracted by an iPad than they are with paper. Future studies could include a larger sample size that includes all the age groups. They may need to have multiple groups for children under 15 because their brains develop each year rapidly. More intervals may provide a more accurate result of children's performance. The participants were also in a stressful environment. Results may differ for different environments. Future studies could include more conditions. Since the test was found online and public, there may be chances that the participants had viewed it before. For the most accurate result, future research could make their own tests. Additionally, the amount of experience the participant has with technology affects their digital reading comprehension (Delgato et al. [10]). Future studies could provide surveys to better understand the participants' level of familiarity with technology.

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Section 4. Economics and management

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UNDERSTANDING THE IMPACT OF COVID-19 ON THE GLOBAL ECONOMY

Abstract. Since the outbreak of COVID-19 in 2020, the world is now struggling with the pandemic. As an important aspect that cannot be ignored at present, it has been affecting us all the time, and many researchers and surveys also focus on it. This study also focuses on COVID-19's recent spread to different continents, the latest cases, and the economic impact. Most of the GDP of Asia and North America are evenly distributed and similar, except that six countries in Asia are higher than all North American countries. The number of new vaccinations is the same in Asia and North America, with the exception of four Asian countries. Overall, the previous assumptions are not applicable to most countries, there is not enough evidence to prove their rationality, and individual exceptions can not explain anything.

Keyword: COVID-19, GDP, economy, impact, correlation, R square.

Introduction

Since the outbreak of COVID-19 in 2020, the world is now struggling with the pandemic. As an important aspect that cannot be ignored at present, it has been affecting us all the time, and many researchers and surveys also focus on it. This study also focuses on COVID-19's recent spread to different continents, the latest cases, and the economic impact. The hypothesis of this study is that there is a weak correlation between the new cases recorded per day and the GDP.

The outbreak of the new virus began in China and spread to many parts of the country in many ways. For example, at the beginning of the outbreak, people did not realize its potential power. So some infected persons were identified as ordinary asthmatic patients and traveled to all parts of the country. Some asymptomatic patients have no obvious symptoms, but carry the virus and can infect others. We therefore assume that at the beginning of the virus outbreak, the number of new cases and deaths in Asia increased, and the economic losses also increased. However, with the gradual development of technology and awareness in the process of fighting COVID-19, China has made great contributions to the more stable epidemic situation. According to the data, on April 4, there were 30 newly confirmed cases in China. At present, novel coronavirus pneumonia cases have exceeded 1 million 200 thousand cases. It has greatly curbed the emergence of new cases, and the economy has gradually recovered from the depression. However, the situation in the Americas continues to deteriorate. The peak number of new cases in a single day in the United States reaches

210000, with an average of 130000 new cases. At the same time, the growth rate of the death toll is amazing. The average death toll is 683 per day. We can't say that the United States has insufficient technical strength to fight the pandemic. Objectively, with the rapid increase of new cases, the United States can't save such a large number of patients at once. Therefore, the number of local deaths will increase with the increase of new cases, and it may improve in the later stage.

I hypothesize that I will observe a weak correlation between the new cases recorded per day and the GDP. This is because countries with stronger economies will be better prepared to implement effective public health measures and their health care systems are more advanced. I also hypothesize that North America has more newly confirmed cases than Asia. As a result, Asia has fewer new vaccinations than North America.

Method

I used R (a programming software that can integrate data and draw considerable charts) to perform data analysis and research on different countries.

I obtained recent COVID-19 data from the online data repository *Our World in Data*. Given the difficulty in downloading the full dataset, my academic consultant provided me with the most recently updated version. This form includes all the data of all continents and countries affected by COVID-19. I focused on a subset of variables for my research. Specifically, I extracted the names of the continents, the number of newly confirmed cases since the outbreak, the number of vaccinations, and GDP from the full dataset.

I then calculated the maximum value for newly confirmed cases and vaccinations administered per day to better understand how the virus was spreading and how well mitigation efforts such as a vaccination program was working.

I read these data into R and built a custom code to obtain relevant statistics and plot three charts. They are: the distribution of the number of newly confirmed cases on all continents, which is in the form of box chart; The relationship between the number of newly confirmed cases and the GDP of each continent is shown as a linear graph; The relationship between the number of newly confirmed cases and the number of vaccinations is shown as a linear graph.

Result

The first box chart (relationship between continents and newly confirmed cases) reflects the newly confirmed cases in six continents. According to the abscissa axis, Africa, Asia, Europe, North America, Oceania and South America are in turn from left to right. First of all, there are almost no cases in Africa in the first column, and the median is close to zero. The upper limit of newly confirmed cases can reach about 400, and there are the most abnormal countries on all continents. Their cases are mainly arranged within 1000, and one is as high as more than 4000. The upper limit in Asia can reach more than 1000, accounting for 50% of the countries with low cases, and there are still two cases as high as 2000 and 3000. All countries in Europe have outbreaks, compared with almost all countries in Oceania. The upper limit in North America is slightly lower than that in Asia, and the distribution is concentrated in 0 ~ 1000 cases.

We performed an Analysis of Variance (ANOVA) to uncover any statistical differences among continents. We found a significant difference ($F = 8.309$; $P = 4.15e\text{-}07$), indicating some continents recorded statistically different maximum case numbers. Indeed, after performing a Tukey's honest significant different test (Tukey HSD), we found Europe reported the highest number of cases per day of any continent, and this was greater when compared to Asia ($P = 0.0162$), and North America ($P = 0.0237$). However, we do find any evidence to suggest that the outbreaks in Asia and North America were statistically different ($P = 1$).

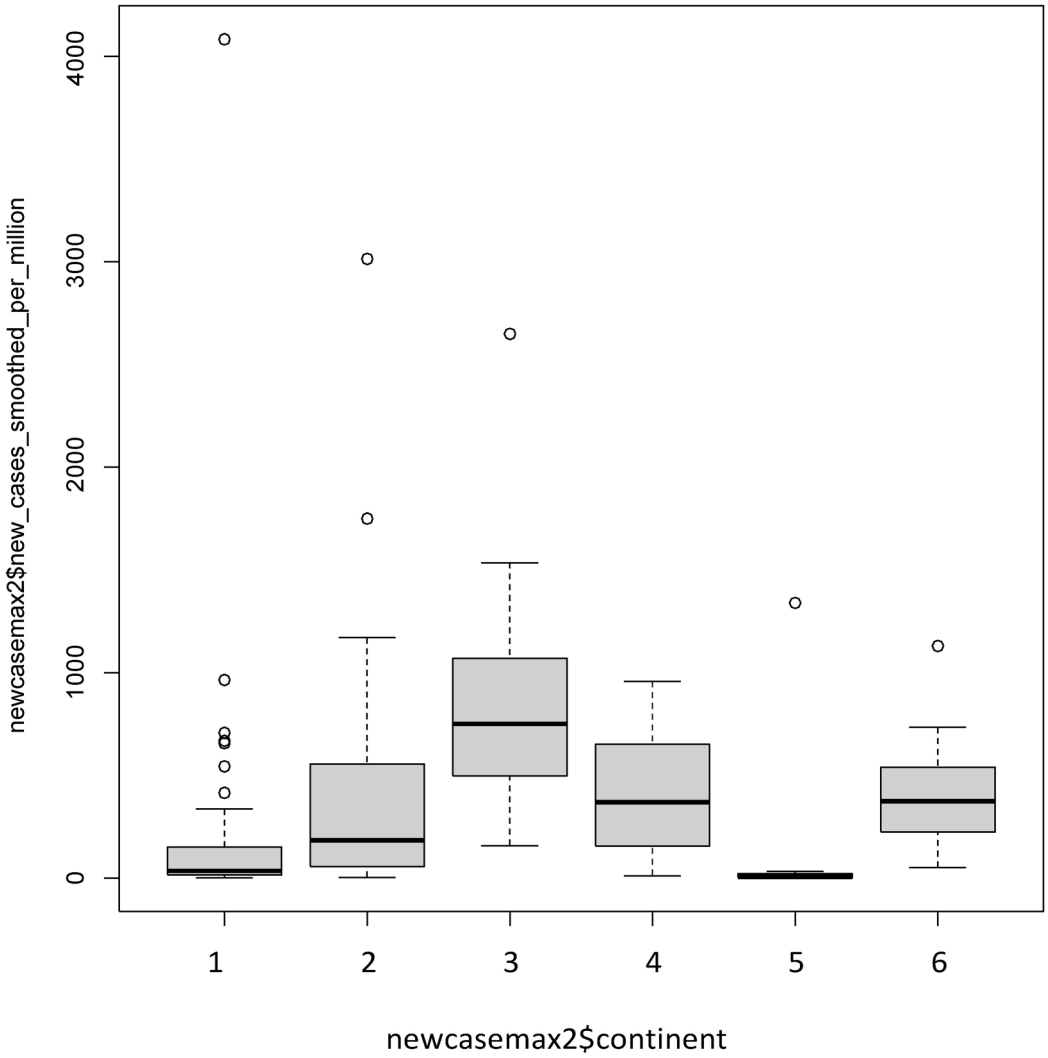

Figure 1. Boxplot of maximum number of cases for each continent. 1, Africa; 2, Asia; 3, Europe; 4, North America; 5, Oceana; 6, South America

The second linear chart (relationship between newly confirmed cases and GDP), six colors: red, blue, black, green, purple and orange. They correspond to six continents: Africa, Asia, Europe, North America, Oceania and South America. The best-fit line follows an upward trend, indicating a positive correlation between cases and GDP ($r^2 = 0.24$; P = = 0.0012). It does not mean that the new cases will lead to the increase of national GDP. On the contrary, the actual situation may happen to be the opposite. In fact, countries with higher GDP have the ability to detect and provide more confirmed people. Other factors are not considered for the time being. The first thing you can see is that there are a large number of points at the bottom left, accounting for most of the points in the whole picture, mainly red, which represents Africa. The number of newly confirmed cases in these regions is less than that in most regions of other continents, ranging from 0 to 1000, and the GDP remains between 0 and 20000. It is striking that the point on the far right is from the Republic of Seychelles, which has a staggering number of confirmed cases of more than 4000, but its GDP remains around 20000. In Asia (blue dots), the distribution is scattered, mostly on the left. It can be seen that the GDP of Asian countries is uneven and fluctuates greatly.

However, the newly diagnosed cases are controlled within 1000. There are more than 1000 in some areas, but most economically developed areas have well controlled the epidemic, such as Singapore, Hong Kong and so on. North America (the Green Point) is also within 1000 cases on the whole. The U.S. GDP is close to 60000, which is the leader in GDP compared with Asia. However, the newly confirmed cases are the largest in other countries in North America and higher than most Asian countries.

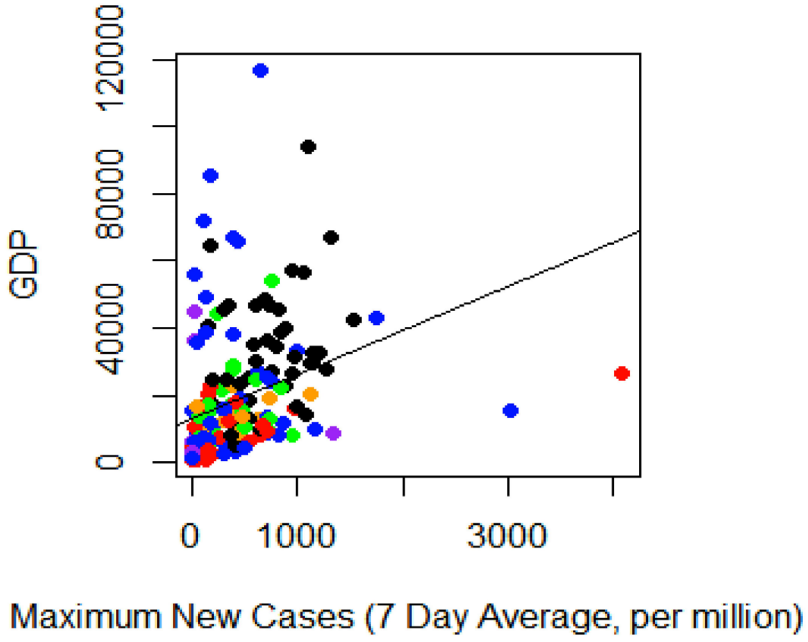

Figure 2a. Maximum new cases regressed against GDP

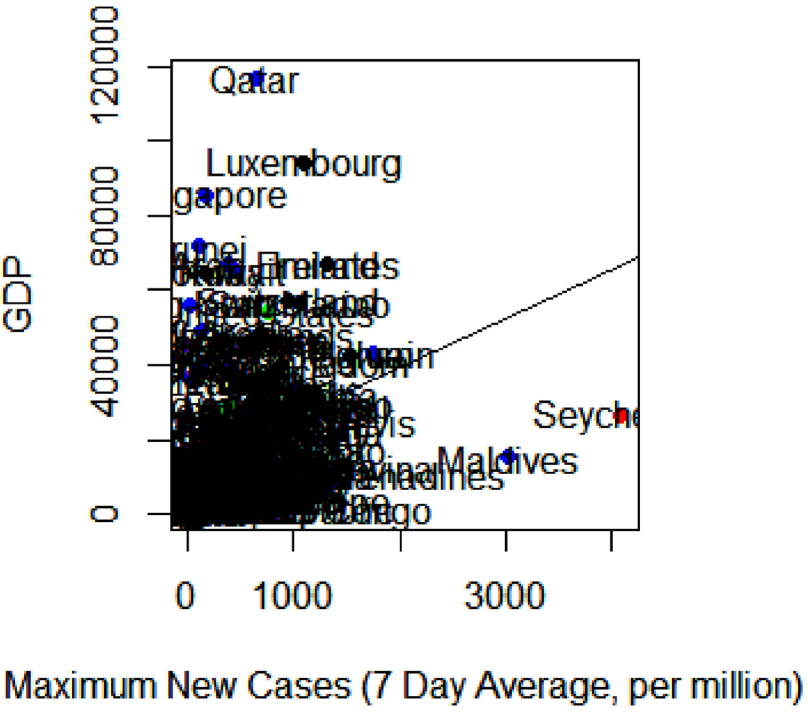

Figure 2b. Maximum new cases regressed against GDP with countries noted

In the third linear chart (the relationship between newly confirmed cases and the number of newly vaccinated vaccines), the change is also positively correlated ($r^2 = 0.21$; $P = 0.0134$). Gathered in the lower left area, Africa still has the lowest number of vaccinations and confirmed cases, with new confirmed cases maintained at 0 ~ 1000 and almost zero number of new vaccinations. However, there are still three African countries, especially the Republic of Seychelles. The distribution in Asia is scattered, mainly in the square area composed of 0 ~ 1000 newly confirmed cases and 0 ~ 20000 newly vaccinated vaccines. There are still four exceptions, especially Bhutan. The distribution of North American countries is more concentrated in the square area composed of 0 ~ 1000 cases and 0 ~ 20000 vaccination numbers. The situation in the United States is more prominent, which is close to the upper right corner of the square area.

Discussion

According to the data results, there is not enough evidence to prove that there are fewer newly confirmed cases in Asia than in North America. Most of them are within 0 ~ 1000. There are no outlier cases in North America, but there are two outlier cases in Asia. There is no significant difference between the two. Let's look at GDP. Most of the GDP of Asia and North America are evenly distributed and similar, except that six countries in Asia are higher than all North American countries. Finally, the number of new vaccinations is the same in Asia and North America, with the exception of four Asian countries. Overall, the previous assumptions are not applicable to most countries, there is not enough evidence to prove their rationality, and individual exceptions can not explain anything. The main reason for this is that the GDP gap between Asia and the Americas is not large. The data show that Asia has the largest economic aggregate, and the gross domestic product (GDP) of 49 countries or regions in Asia is about US.

$28.63 trillion. The GDP of 37 countries or regions in North America in 2017 was US $27.002 trillion@4. This is why, on the whole, there is little gap between North America and Asia. The amount of GDP largely determines the average development level of the continent, whether the medical equipment and scientific and technological development are advanced or not. This is why in terms of GDP, the countries with several extreme cases are mostly Asia. The GDP is related to the country's ability to produce more vaccines. The higher the GDP, the more developed the national economy is, the stronger the vaccine R & D ability is, and the more vaccines can be developed. This is why the GDP is directly proportional to the number of new vaccines, and most extreme cases appear in Asia. As for why the higher the GDP, the more new confirmed cases in continents, and many extreme cases appear in Asia, this is because the higher the economy, the more capable the continent is to survey population and take care of the majority of citizens. On the contrary, Africa has a very small number of newly confirmed cases, and the average case is close to 0, because in many small countries in Africa, the government does not have enough economic capacity to test for COVID-19. It may be true that the disease is not so serious in some places, but the less economically developed countries in Africa account for the majority. Many people are ill, have no ability to receive vaccines, have not been tested, or even die directly, resulting in the lack of some data. On the contrary, there are extreme countries in Asia, such as Hong Kong, Singapore and Qatar countries. As can be seen from the figure, its GDP value stands out from many countries, especially Qatar. Due to its rich oil resources, it has become one of the richest countries in the world. Its country is small, with a population of only 2.88 million, but its cases exceed most African countries, and its case reporting is more accurate. However, the country is not particularly prominent in vaccination, which may be caused by the weak national awareness. China has such a large population and such a complex number of national conditions. In order to establish an effective defense line for epidemic prevention and control, the number

of vaccinated population must reach at least 1 billion, that is, the vaccination rate of 1.4 billion people must reach more than 70%, so as to establish an effective defense line for epidemic prevention and control. can be seen from the figure, there are not enough examples to confirm the original hypothesis.

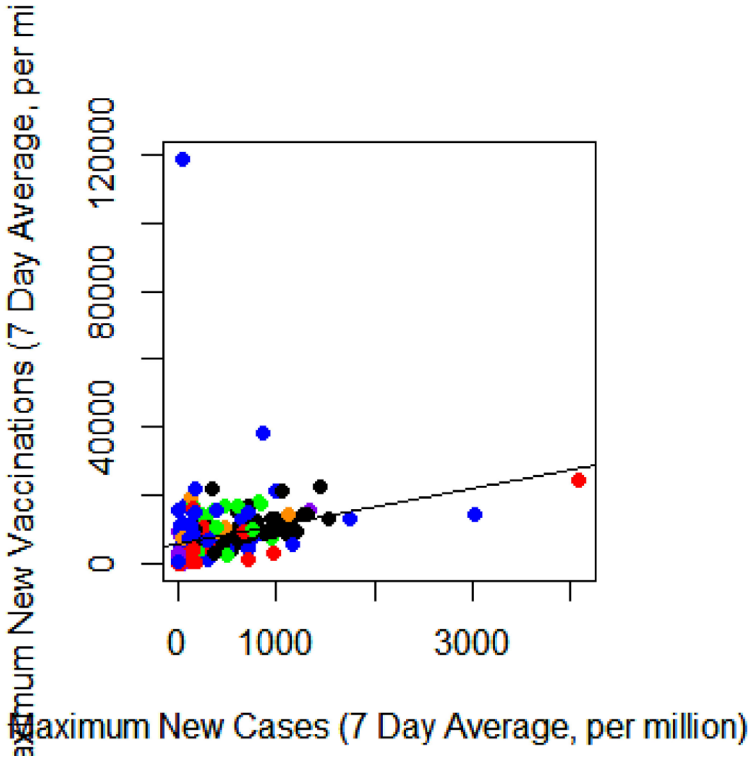

Figure 3 a. Maximum new cases regressed against maximum new vaccinations

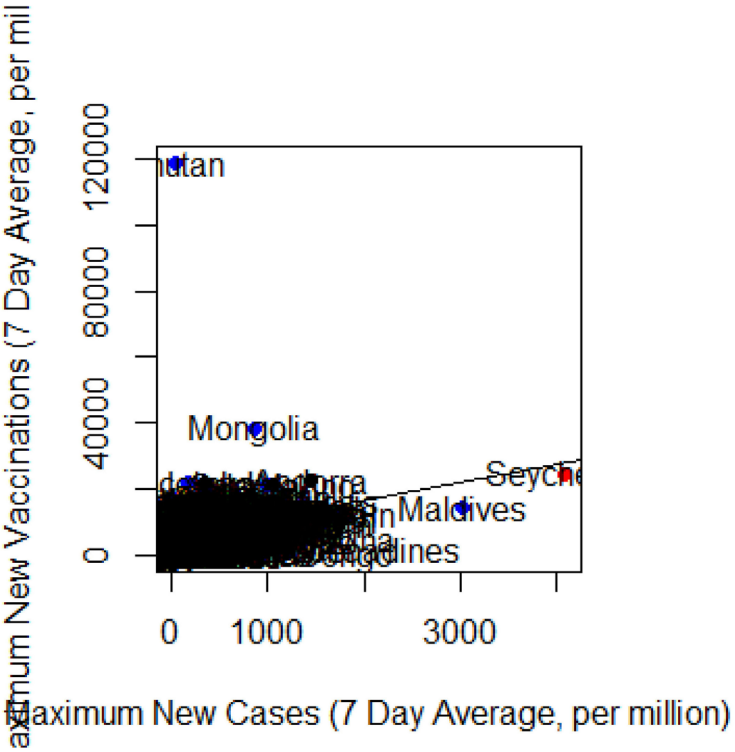

Figure 3 b. Maximum new cases regressed against maximum new vaccinations with countries noted

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